Microparity single photon product introduction

1.MPT2321

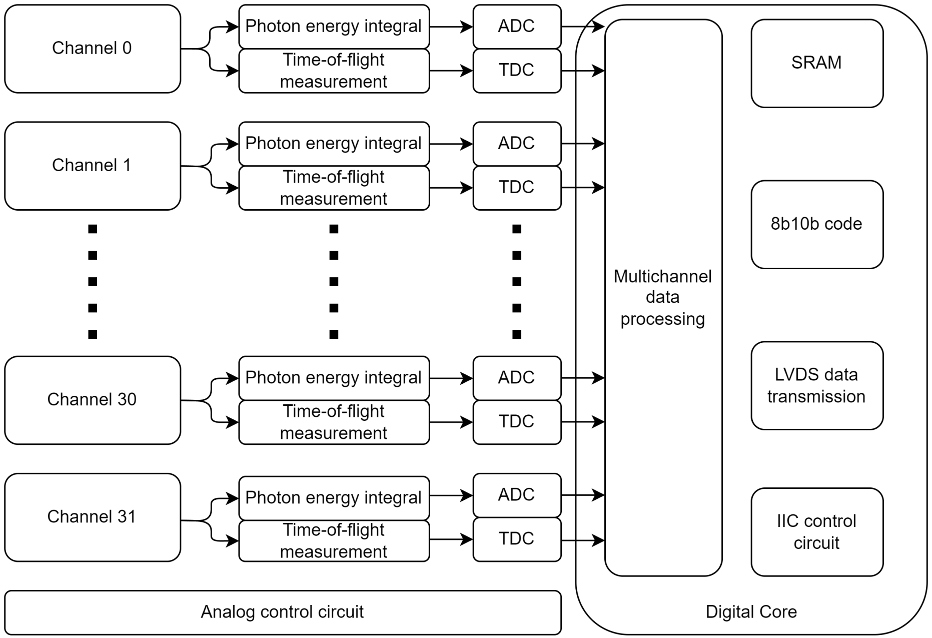
Product overview

MPT2321 is ASIC for high-precision SiPM time-of-flight signal processing.A total of 32 channels are available to capture and process the time and energy information of SiPM,each channel with independent gain selection and threshold comparison,and the appropriate signal measurement range can be customized or automatically selected.At the same time, the high-precision ADC and TDC on each channel measure the signal energy and time of flight.The measurement data is transmitted through multiple high-speed serial differential data interfaces.MPT2321 is compatible with a wide range of commercial SiPM sensors for medical imaging and liDAR signal processing, and is particularly suitable for highly integrated, low-cost applications with PET/CT systems.

MPT2321 10mm*10mm 144 BGA package

Architecture

- 32 analog input channels
- Each channel contains one ADC and one TDC
- Two independent time synchronization channels
- All channels share a PLL
- Supports both positive and negative polar input
- Change the working status of the chip through the IIC



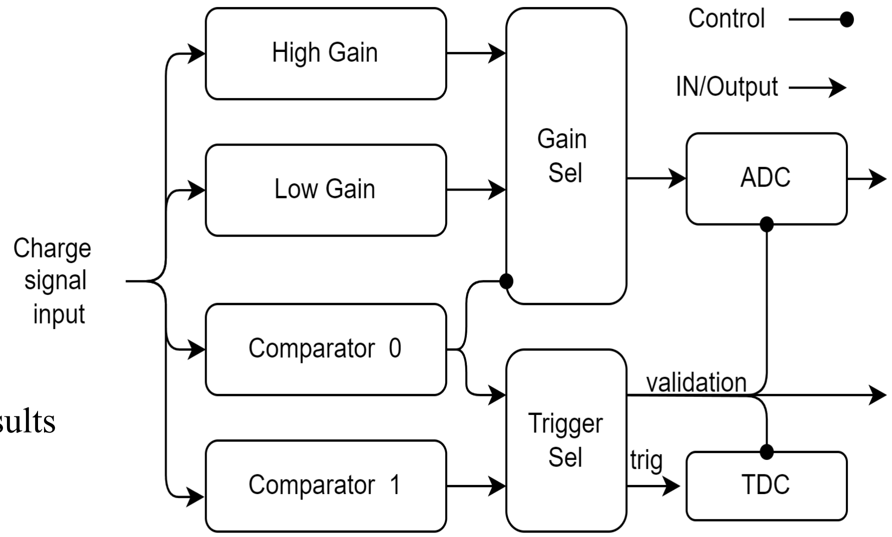
MPT2321 architecture framework

Main performance index

Parameter name	index	Parameter name	index
Charge measurement mode	Integral forming	Timing mode	Leading edge timing
Number of simulated input channels	32	SiPM input polarity	Support positive and negative
Synchronizing time measurement channels	2	Single channel average power consumption	< 15mW
Upper limit of charge measurement range	1.8nC	ASIC measures time accuracy	RMS < 50ps
Threshold LSB	< 0.3p.e.	Single photon gain calibration	support
Charge measurement ADC	On-chip integration	Timing measurement TDC	On-chip integration
ADC bits	12	TDC LSB	50-200ps
ADC DNL	< 0.5	Energy over threshold screening	support
Chip control mode	IIC	PLL locks the upper limit	160M
Maximum IIC rate	1M	Data transmission interface	LVDS
Gain select gear	7	Number of data transmission	5
Single photon SNR	> 10	Data size of a single event	40bit
TDC calibration	support	Average channel event rate	500kcps

Analog signal processing flow

- The analog input was copied in 4 copies
- Two copies for different gains
- Two copies of the threshold comparison
- The gain is automatically selected by comparing the results
- Supports single or double thresholds
- Automatic/fixed gain selection is supported



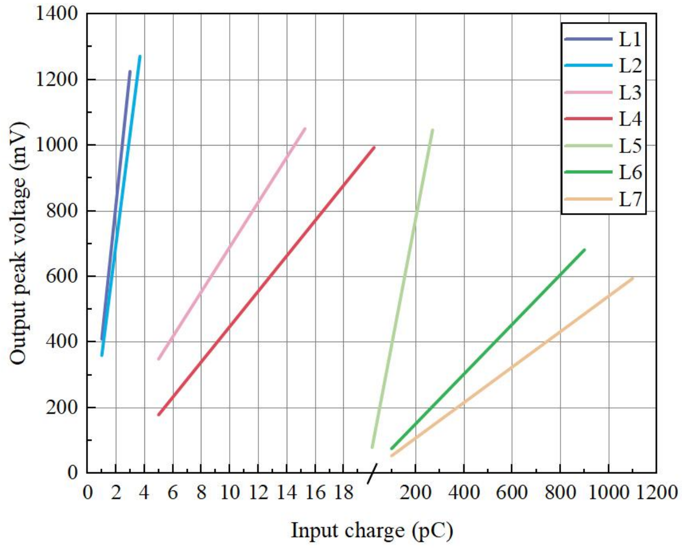
Analog signal processing flow

Gain SNR and Dynamic range

1.2pf capacitor to inject about 360fc charge pulse into the analog channel, and the SNR is maintained at 12~14 at the highest gain.

Nonlinearity 1% of Dynamic range：
3pC, 3.7pC, 15.2pC, 28.2pC(High Gain)
270pC, 900pC, 1100pC(Low Gain)

Nonlinearity 5% of Dynamic range：
3.7pc, 4.3pC, 17.6pC, 32.9pC(High Gain)
330pC, 1300pC,1500pC(Low Gain).



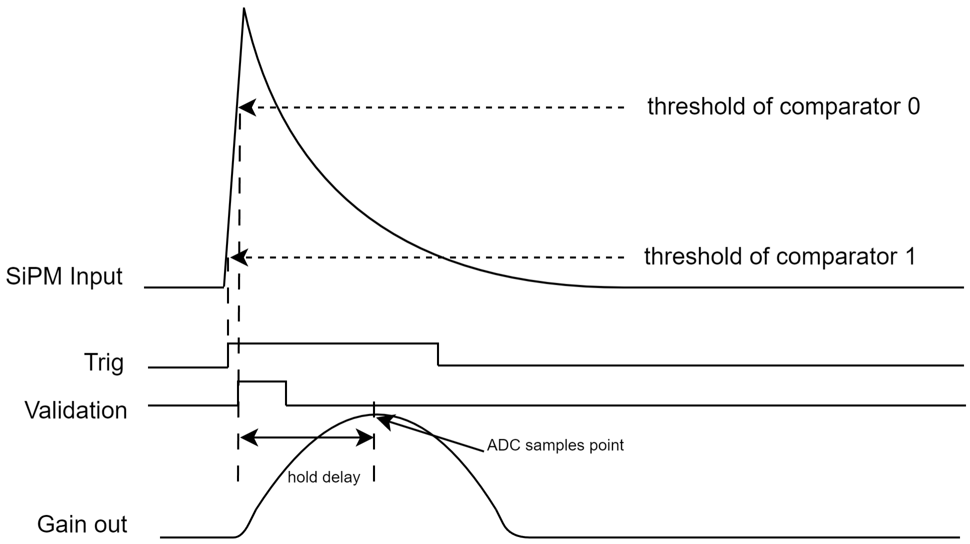
Relationship between injection charge and gain output voltage

The logic of trig and getting data

Comparator 1 generates Trig for TDC timing

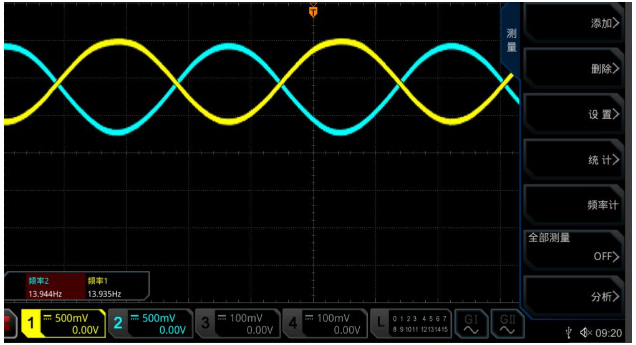
Comparator 0 generates Validation to determine that the event is valid

ADC peak sampling

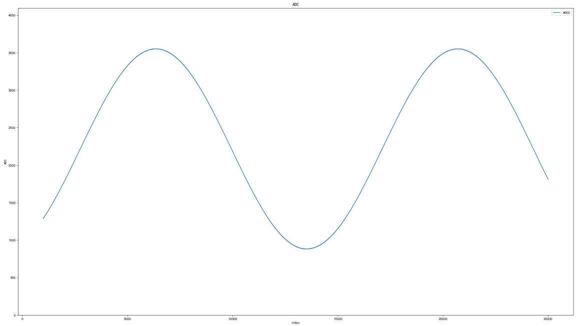


ADC

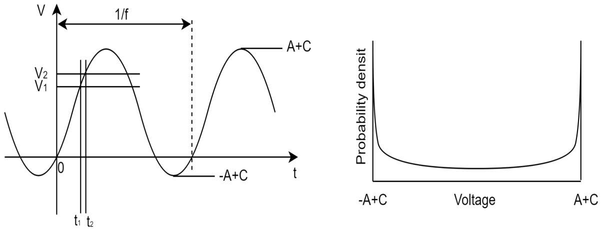
12bit 1mV precision differential ADC



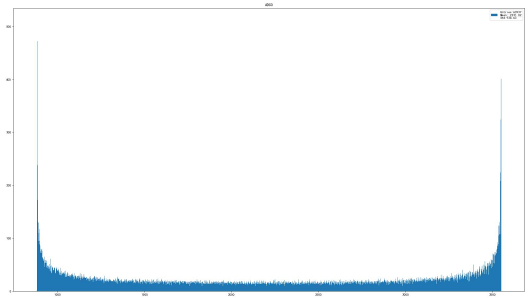
ADC injection signal



ADC sampling plot



Ideal injection signal diagram and probability density distribution



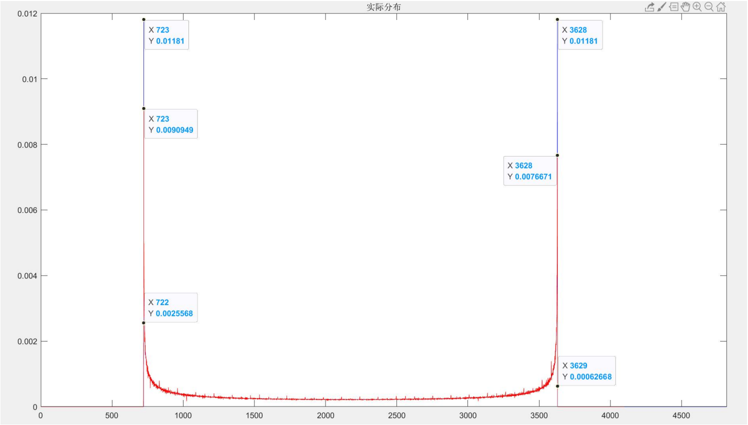
ADC sampling hist or Actual probability density distribution

ADC

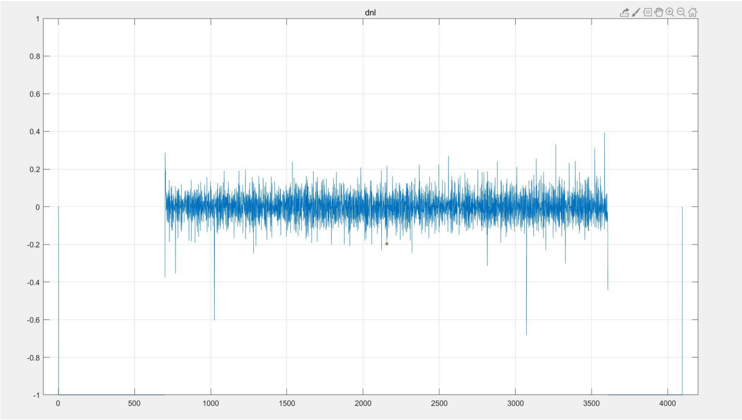
Ideal probability density algorithm： $$P(actual) = \frac{2(t_2 - t_1)}{(\frac{1}{f})} = \frac{1}{\pi}\left\{sin^{-1}\left(\frac{V_2 - C}{A}\right) - sin^{-1}\left(\frac{V_1 - C}{A}\right)\right\}$$

Actual probability density: P(actual) = number of events at an ADC code / total number of events

Using this algorithm： DNL = P(actual) / P(ideal) - 1

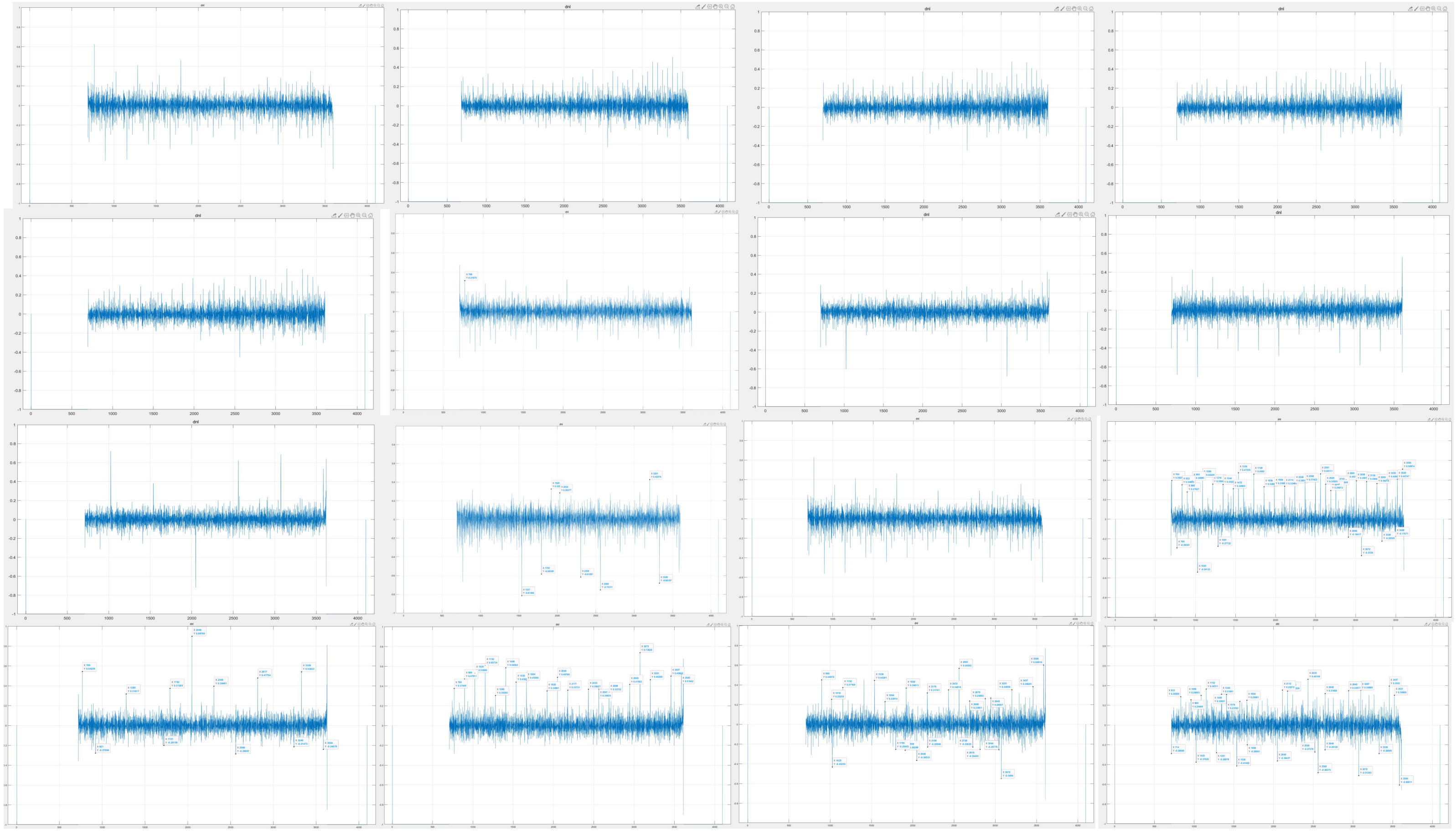


Probability density distribution
Red is actual
Blue is ideal



ADC DNL
DNL = -1Means that the code value is missing or the input sine wave is not covered

ADC

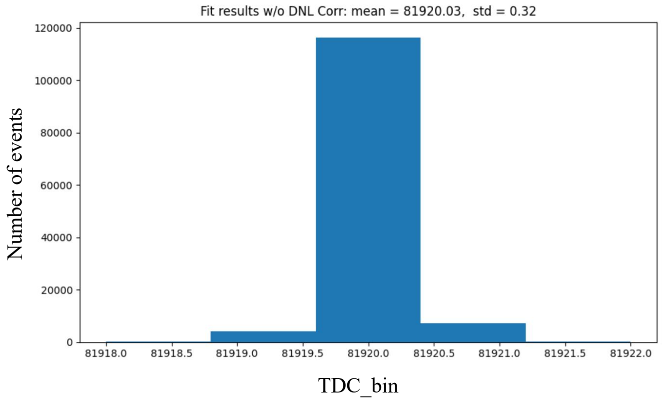


ADC_DNL test results for different channels

TDC

18bit minimum 48.828125ps resolution TDC

TDC injection signal
f = 250kHz T = 4us



TDC data difference histogram

TDC_LSB: 48.828125 ps

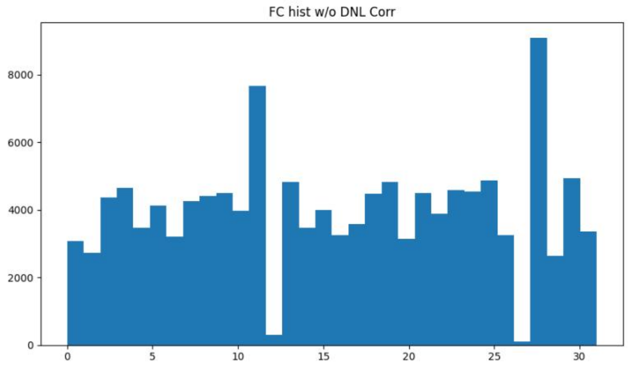
T form TDC data = mean_TDC data difference * TDC_LSB ≈ 4,000,001.46484375 ps

$$\sum = std*TDC\_LSB/\sqrt{2}\ (0.32 * 48.8)/\sqrt{2} = 11$$

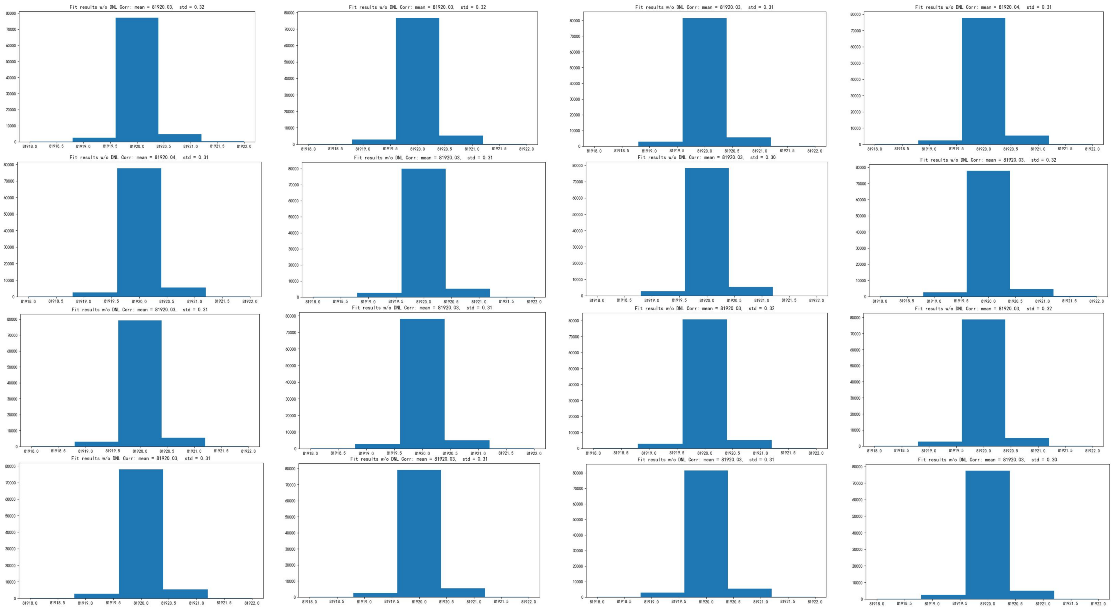
TDC

宇称电子 MICROPARITY Sensor and Science

We test different channels of the same chip using the page up method

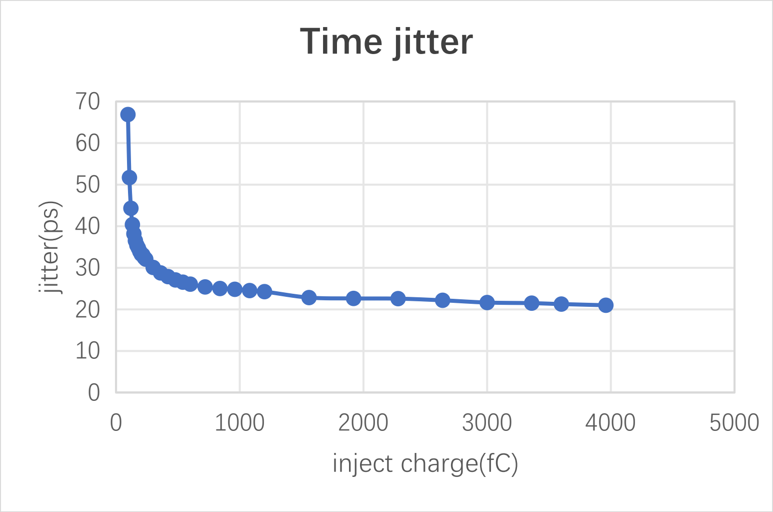


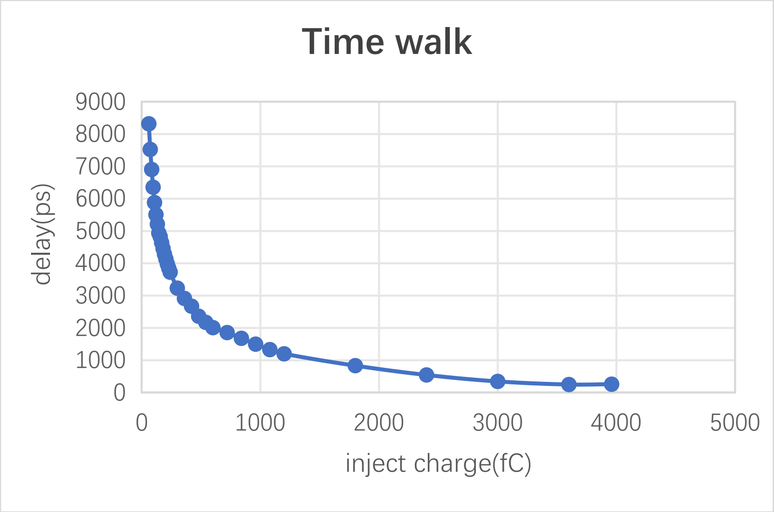
TDC Minimum 5bit code distribution



Time walk and Time jitter

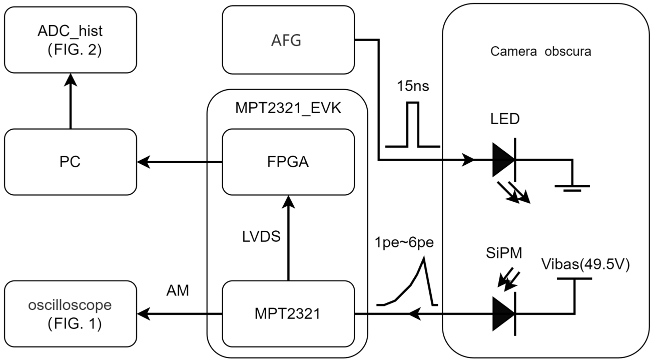
We injected charge pulses into two analog channels and used conjugate gradient method to first find out the optimal threshold of comparator 1 of the two channels. Adjust the amount of charge injected into another channel, record the TDC difference between the two channels (delay) and the std/√2 (jitter) of the difference.





Example 1

We use the following device to generate pulse signals through AFG to control LED strobe light, control the amplitude of pulse signals to ensure that SiPM (S15639-1325PS) receives 1~6 photons, and finally observe its waveform shape through an oscilloscope. The ADC data histogram collected by MPT2321 was used to observe the energy distribution of different photon numbers.



Single photon test structure

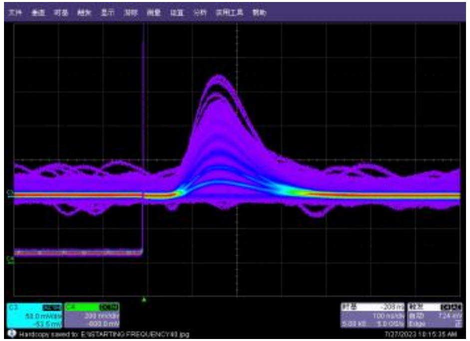


FIG. 1 Single photon waveform observed by AM

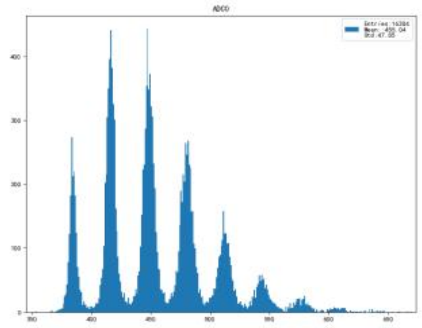
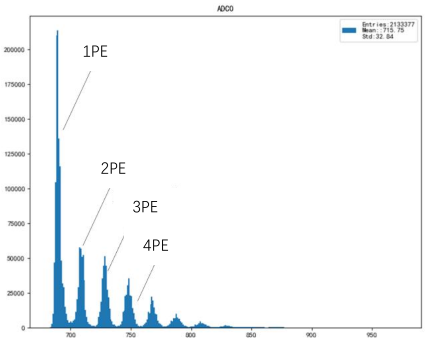


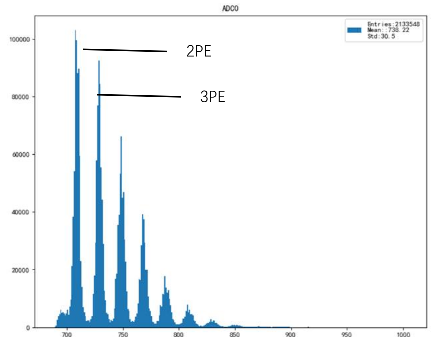
FIG. 2 ADC histogram of MPT2321 acquisition

Example 2

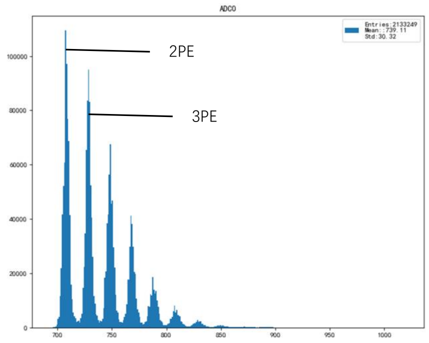
In example 1, we only use comparator 1 mode, adjust the threshold of comparator 1, and gradually filter out the threshold of passing through MPT2321 for photons below a certain energy level. Through testing, in this case, the threshold LSB is about 1/3photon energy.



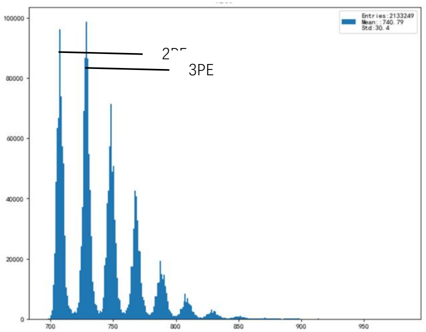
Threshold 1



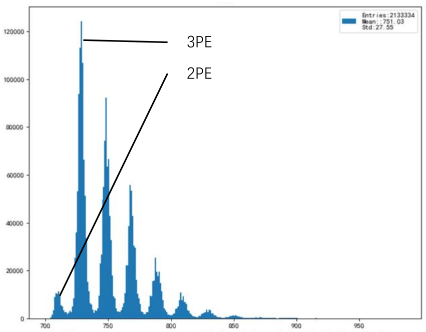
Threshold 1+LSB



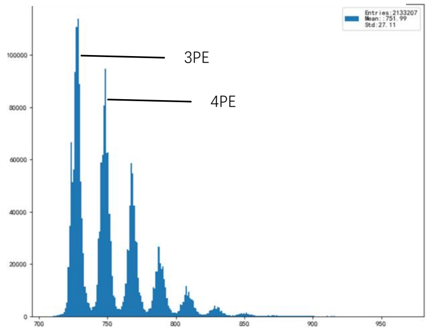
Threshold 1+2LSB



Threshold 1+2LSB



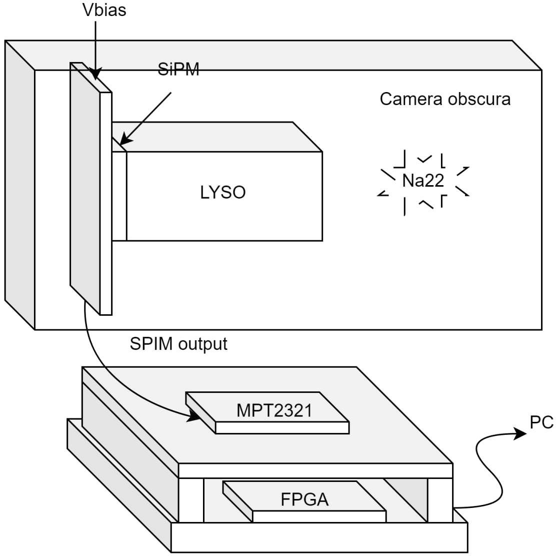
阈值：05　（第二能级叠加正向噪声能通过）



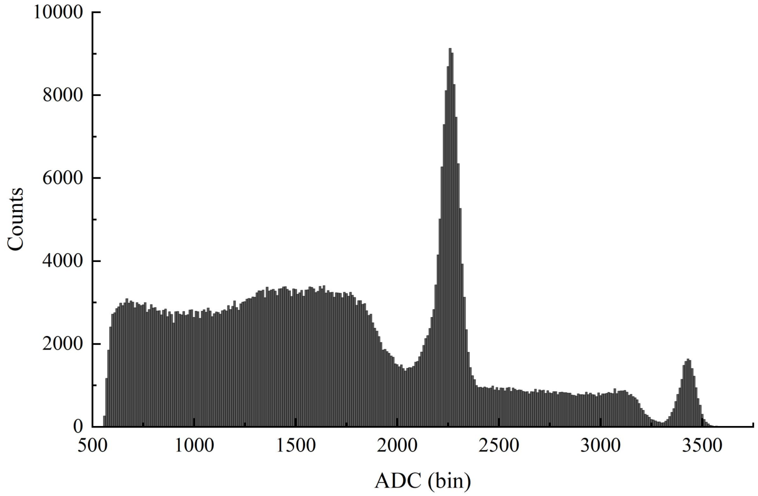
阈值：06　（第三能级）

Example 3

We used LYSO+SiPM as a detector, placed Na22 around the detector, and the output of SiPM was directly connected to the analog input of MPT2321. Through gain and ADC sampling, the energy spectrum of Na22 radioactive source was collected,the photopeak energy resolution of 511KeV is about 7.72%.



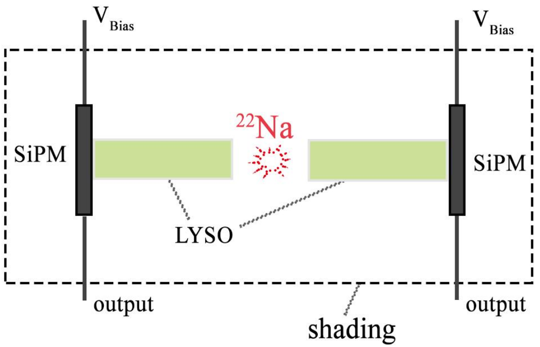
Na22 test structure



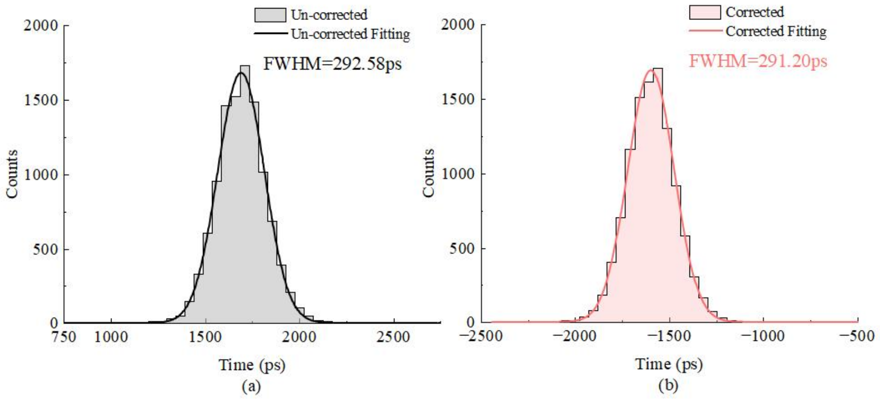
Na22 Energy spectrum

Example 4

On the basis of example 4, we increase the number of detectors to 2 and do the time coincidence test on Na22. Get the test results below



Time coincidence test structure



Time coincidence result

2.MPT2042

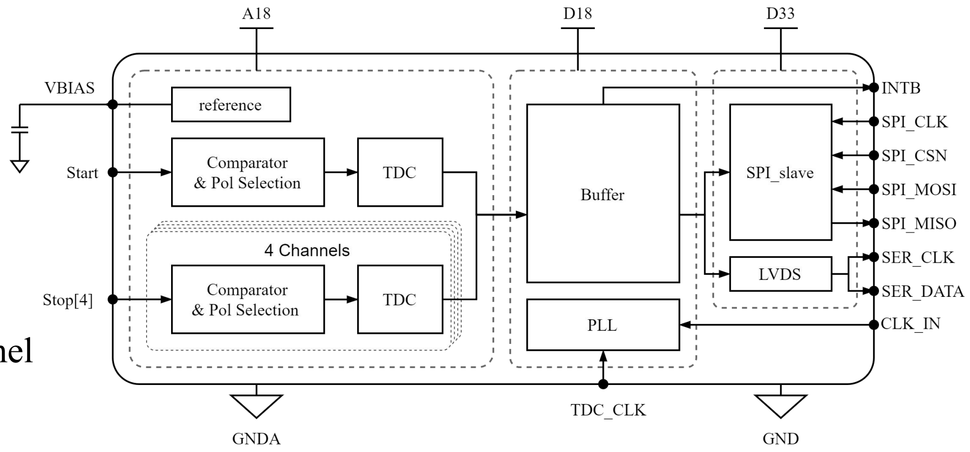
Product overview

MPT2321 is ASIC for high-precision SiPM time-of-flight signal processing.A total of 32 channels are available to capture and process the time and energy information of SiPM,each channel with independent gain selection and threshold comparison,and the appropriate signal measurement range can be customized or automatically selected.At the same time, the high-precision ADC and TDC on each channel measure the signal energy and time of flight.The measurement data is transmitted through multiple high-speed serial differential data interfaces.MPT2321 is compatible with a wide range of commercial SiPM sensors for medical imaging and liDAR signal processing, and is particularly suitable for highly integrated, low-cost applications with PET/CT systems.

MPT2042 5mm*5mm QFN32 package

Architecture

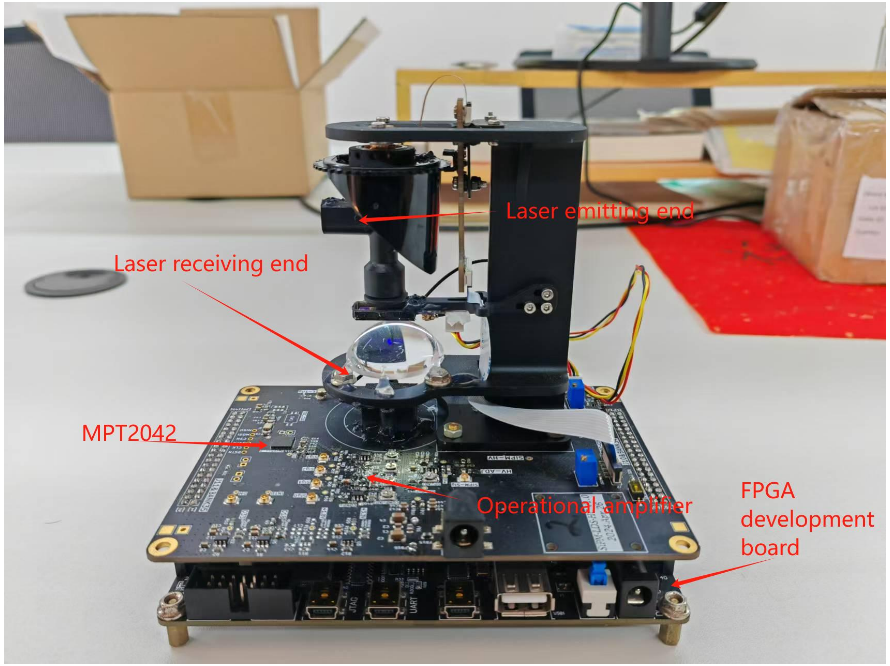
- 4 stop signal input channels and 1 start signal input channels
- 25ps time resolution 18bit TDC
- Supports both positive and negative polar input
- Individual high-speed comparator and TDC per channel
- Supports output strat-stop interval or independent timestamp
- Change the working status of the chip through the SPI



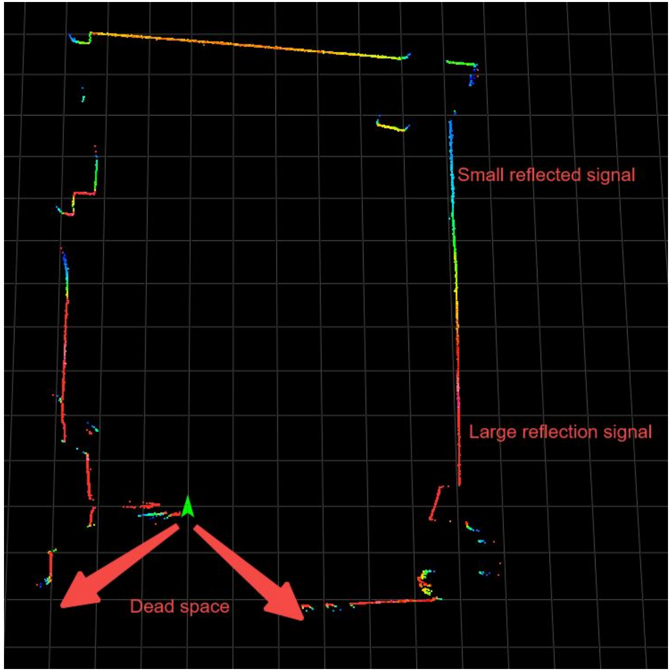
MPT2042 architecture framework

Example

We built a 2D scanning kit consisting of MPT2042, SiPM, rotating laser and part of the optical path, which was placed in ourexhibition hall and scanned the outline of the exhibition hall



MPT2042 2D rotary scanning system



MPT2042 2D scan of the company exhibition hall

3.MPX105

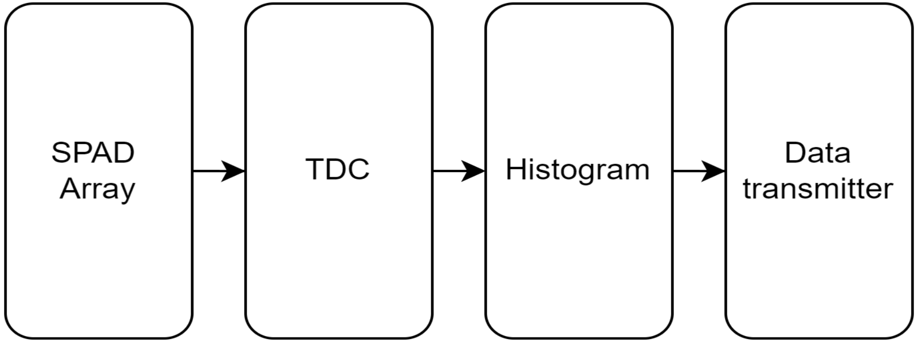
Product overview

MPX105 is single-point dToF ranging sensorbased on SPAD technology, featuring fastresponse time and low power consumption. ltis primarily used in robotic vacuum navigation/obstacle avoidance, drone altitude maintenance/obstacle avoidance, ranging and proximity sensing, and industrial detection.

MPX105 5mm*5mm QFN32 package

Architecture

- Region ofinterest (ROl) selection
- SPAD PDE: 9%@905 nm
- Range up to 15m
- Frame rage up to 7.2KHZ
- Distance and intensity data out
- lC/SPI interface

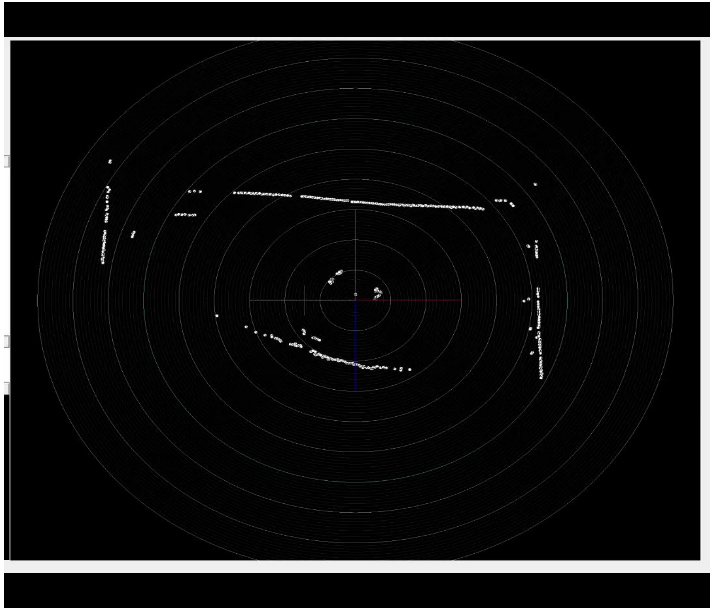


MPX104 architecture framework

Example

We also built a two-dimensional scanning kit composed of MPX104, rotating base and laser optical path, which was placed in our exhibition hall to scan the outline of the exhibition hall,By placing this device on the ground, we can clearly see the outline of the entire exhibition hall and the trajectory of the testers.

MPX104 2D rotary scanning system

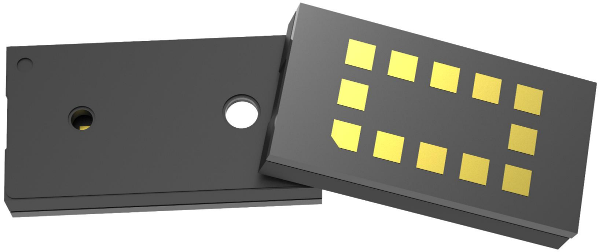


MPX104 2D scan of the company exhibition hall

4.MPX118

Product overview

MPX118 is a 4x4 or 8x8 small area SPAD single photon detector array with high precision and low power consumption. lt provides accurate ranging with a maximum distance of up to 5 meters and a wide field of view. lt can be used in autofocus assistance, gesture recognition, drone altitude maintenance/obstacle avoidance, andLiDAR applications.



MPX118 package

Architecture

- Multizone ranging output with either 4x4 or 8x8 separate zones

- High integration and low power

- Range up to 5m

- Up to 60 FoV

- llC interface

宇称电子

MICROPARITY

Sensor and Science